DESCRIPTION

The IS32LT3965 is a synchronous DC/DC switching LED driver that integrates high-side and low-side N-channel MOSFETs to operate in a Buck configuration. The device can operate from a wide input voltage between 3.8V and 38V and provides a constant current of up to 1.5A for driving a single LED or multiple series connected LEDs.

The external resistor, R_{IS}, is used to set a constant LED output current, while allowing the output voltage to be automatically adjusted for a variety of LED configurations.

The IS32LT3965 operates in a fixed frequency mode during switching, up to 2.2MHz. There is an external resistor connected between the VCC and TON pins used to configure the on-time (switching frequency). The switching frequency is dithered in spread spectrum operation which spreads the electromagnetic energy over a wider frequency band. This function is helpful for optimizing EMI performance.

A logic input PWM signal applied to the enable (EN/PWM) pin will adjust the average LED current by its PWM duty cycle. The EN/PWM pin also can be used to program an additional UVLO protection. The analog dimming pin ICTRL can implement LED dimming or LED string thermal roll-off protection.

True average output current operation is achieved with fast transient response by using cycle-by-cycle, controlled on-time method.

The IS32LT3965 is available in a WFCQFN-14 (3mm x 4mm) package with wettable flanks. It operates from 3.8V to 38V over the temperature range of -40°C to +150°C.

QUICK START

Figure 1 *Photo of IS32LT3965 Evaluation Board*

FEATURES

- Wide input voltage supply from 3.8V to 38V
- High-side sense and true average output current control, up to 1.5A maximum over temperature range
- Operating frequency up to 2.2MHz
- Forced Continuous Conduction Mode (FCCM) operation
- Integrated high-side and low-side MOSFET switches
- Cycle-by-cycle current limit
- Dimming via PWM logic input or analog voltage
  - Supports LED thermal roll-off or LED binning
- Internal control loop compensation
- Externally programmable undervoltage lockout (UVLO)
- 1μA low power shutdown
- Spread spectrum to optimize EMI
- Robust fault protection and reporting function:
  - Pin-to-GND short
  - Component open/short faults
  - LED string open/short
  - Junction thermal roll-off
  - Thermal shutdown
  - Shared fault flag for multiple device operation to comply with “one-fail-all-fail” function
- AEC-Q100 Qualified
- RoHS & Halogen-Free compliant package
- TSCA compliant

RECOMMENDED EQUIPMENT

- 38VDC power supply
- LED array
- Multi-meter

RECOMMENDED INPUT AND OUTPUT RATINGS

- Input: 4V~38VDC
- Output: 1~10 LEDs in series.

ABSOLUTE MAXIMUM RATINGS

- Input voltage ≤ 38VDC

Caution: Do not exceed the conditions listed above, otherwise the board will be damaged.

PROCEDURE

The IS32LT3965 DEMO Board is fully assembled and tested. Follow the steps listed below to verify board operation.

Caution: Do not turn on the power supply until all connections are completed.

1) Connect the positive terminal of the power supply

to the VCC of the board and the negative terminal of the power supply to the GND of the board.

2) Connect the cathode of the LED panel (LED arrays) to the LED- terminal and connect the anode of the LED panel (LED arrays) to the LED+ terminal.

3) To test PWM dimming, apply an external PWM signal to the EN/PWM terminal of the board. If PWM dimming is not used, close the jumper JP1 and the output PWM will be 100%.

Note: if connect PWM signal to the EN/PWM terminal, the JP1 must be open to avoid PWM generator damage due to the high voltage on the VCC pin.

4) To test analog dimming, apply an external 0.88V~2.4V voltage signal to ICTRL terminal of the board. If analog dimming is not used, leave ICTRL floating and the output will be 100%.

5) Turn on the power supply and the LED panels (LED arrays) will be lighted up.

6) FAULTB is the fault reporting output, which is pulled up to VDD by R5 on board. It will be pulled low whenever a fault condition is detected. Please refer to table 3 for more details on fault conditions. If not tested, leave FAULTB terminal floating.

ORDER INFORMATION

Part No.	Temperature Range	Package
IS32LT3965-QWCLA3-EB	-40°C to +125°C (Automotive)	WFCQFN-14, Lead-free

Table 1 *Ordering Information*

For pricing, delivery, and ordering information, please contacts Lumissil's analog marketing team at analog@Lumissil.com or (408) 969-6600.

DETAILED DESCRIPTION

OUTPUT CURRENT SETTING

The LED current is configured by an external sense resistor, R_{IS}, with a value determined by the following Equation (1):

$$I_{LED} = \frac{V_{IS}}{R_{IS}} \qquad (1)$$

Where the analog dimming function is disabled (V_{ICTRL}>2.4V) and V_{IS} = 0.2V (Typ.).

Note that R_{IS}= 0.133Ω is the minimum allowed value for the sense resistor in order to maintain the switch current below the specified maximum value.

Table 2 R_{IS} Resistance Versus Output Current

R_{IS} (Ω)	Nominal Average Output Current (mA)
0.3	667
0.2	1000
0.133	1500

The resistor R_{IS} should be a 1% resistor with enough power tolerance and good temperature characteristic to ensure accurate and stable output current.

FREQUENCY SELECTION

During switching the IS32LT3965 operates in a constant on-time mode. The on-time is adjusted by the external resistor, R_{TON}, which is connected between the VCC and TON pins.

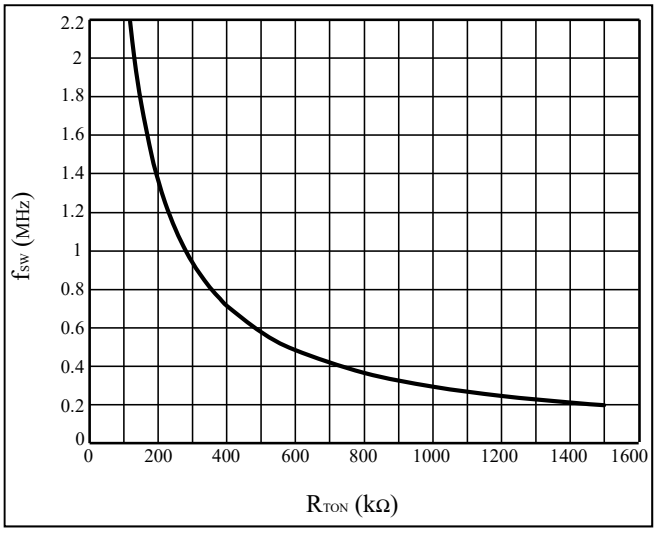

Figure 2 *Operating Frequency vs. R_{TON} Resistance*

The approximate operating frequency can be calculated by below Equation (2):

$$f_{SW} = \frac{1}{k \times (R_{TON} + R_{INT}) + 0.037} \qquad (2)$$

Where k= 0.00333, with f_{SW} in MHz, R_{TON} and R_{INT} (internal resistance, 20kΩ) in kΩ.

Higher frequency operation results in smaller component size but increases the switching losses. It may also increase the high-side MOSFET gate driving current and may not allow sufficient high or low duty cycle. Lower frequency gives better performance but results in larger component size. In automotive applications, an operating frequency of 400kHz or 2.2MHz is good choice to compromise for both component size and efficiency while keeping the

switching noise out of the sensitive frequency bands to easily pass EMI test.

ANALOG DIMMING

The IS32LT3965 also offers an analog dimming function on input pin, ICTRL, whose dimming voltage range is V_{ICTRL_MIN} (typical 0.88V) to V_{ICTRL_MAX} (typical 2.4V). The current sense voltage threshold, V_{IS}, can be regulated by the ICTRL pin voltage. If the ICTRL pin is pulled up above V_{ICTRL_MAX}, analog dimming is disabled and the output current is given by Equation (1). When the ICTRL voltage (V_{ICTRL}) is driven within V_{ICTRL_MIN} to V_{ICTRL_MAX}, V_{ICTRL} will proportionally control the current sense voltage threshold V_{IS} resulting in a linear change in the output current as given by Equation (3):

$$I_{LED\_ICTRL} = \frac{V_{ICTRL} - 0.8V}{1.6V} \times \frac{V_{IS}}{R_{IS}} \qquad (3)$$

FAULT HANDLING

The IS32LT3965 is designed to detect the following faults and report via open drain FAULTB pin:

Pin open

- Pin-to-ground short
- Output LED string open and short
- External component open or short
- Thermal shutdown

Please check Table 3 for the details of the fault actions.

The FAULTB pin is an open drain structure. If the device detects a fault condition, the FAULTB pin will go low to report the fault condition, which can be monitored by an external host. The FAULTB pin supports both input and output functions. Externally pulling FAULTB pin low will disable the device. For lighting systems with multiple IS32LT3965 drivers that requires the complete lighting system to shut down when a fault is detected, the FAULTB pin can be used in a parallel connection. A fault output by one device will pull low the FAULTB pins of the other parallel connected devices and simultaneously turn them off. This satisfies the “one fail all fail” operating requirement.

This pin requires an external pull up resistor (R_{FPU}) for normal operation. Do not allow to float. The recommended R_{FPU} value is 10kΩ.

Table 3 Fault Actions

Fault Type	LED String	Detect Condition		FAULTB Pin		Fault Recovering
Inductor short	Dim	Trigger OCP. Turn off high-side MOSFET immediately. Retry after 10ms.		Pull Low immediately		Inductor short removed. No OCP triggered and FAULTB pin recover after 10ms.
R_{IS} short	Dim	Trigger OCP. Turn off high-side MOSFET immediately. Retry after 10ms.		Pull Low immediately		R_{IS} short removed. No OCP triggered and FAULTB pin recover after 10ms.
R_{IS} open	Off	Detect high differential sense voltage. Turn off high-side MOSFET immediately. Retry after 10ms.		Pull Low after 20us deglitch time.		R_{IS} open removed. FAULTB pin recover after 10ms.
LED string open	Off	No PWM dimming:	Low R_{IS} voltage trigger EAO (Error Amplifier Output) high-clamp for 10ms.	No PWM dimming:	Pull Low after 10ms.	LED open removed. FAULTB pin recover after 10ms.
		PWM dimming:	Low R_{IS} voltage trigger EAO (Error Amplifier Output) high-clamp after 20us deglitch time and keeps for 16 PWM cycles.	PWM dimming:	Pull low after 16 PWM cycles.	
LED string short	Off	No PWM dimming:	Filter V_{LX} to get V_{OUT}, if V_{OUT}<1.45V for 10ms	No PWM dimming:	Pull Low after 10ms.	Short removed. V_{OUT}>1.65V for 10ms and FAULTB pin recover after 10ms.
		PWM dimming:	Filter V_{LX} to get V_{OUT}, if V_{OUT}<1.45V after 20µs deglitch time and keeps for 16 PWM cycles.	PWM dimming:	Pull low after 16 PWM cycles.	
BOOT capacitor open	Dim	V_{CC}-V_{LX}>2V at high-side MOSFET ON (High-side can't fully turn on). Turn off high-side MOSFET immediately. Retry after 10ms.		Pull Low immediately		BOOT capacitor open removed, V_{CC}-V_{LX}<2V for 10ms and FAULTB pin recover.
BOOT capacitor short	Off	Bootstrap circuit UVLO and turn off high-side MOSFET immediately.		No PWM dimming:	Pull Low after 10ms.	BOOT capacitor short removed. Release from UVLO and FAULTB pin recover after 10ms
				PWM dimming:	Pull low after 16 PWM cycles.	
R_{TON} resistor open	Dim	On-time exceeds 20µs or trigger OCP, then turn off high-side MOSFET immediately. Retry after 10ms.		Pull Low immediately		R_{TON} resistor open removed. No over 20us on-time or OCP triggered. FAULTB pin recover after 10ms
R_{TON} resistor short	Dim	The device operating at minimum on/off time, maybe trigger the other fault conditions.		No reporting		R_{TON} resistor short removed.
VOUT/ISP short to GND	Off	Trigger OCP. Turn off high-side MOSFET immediately. Retry after 10ms.		Pull Low immediately		Short removed. FAULTB pin recover after 10ms.
Thermal Shutdown	Off	The die temperature exceeds 170°C		Pull Low immediately		The die temperature cools down below 150°C. FAULTB pin recovers after 10ms.

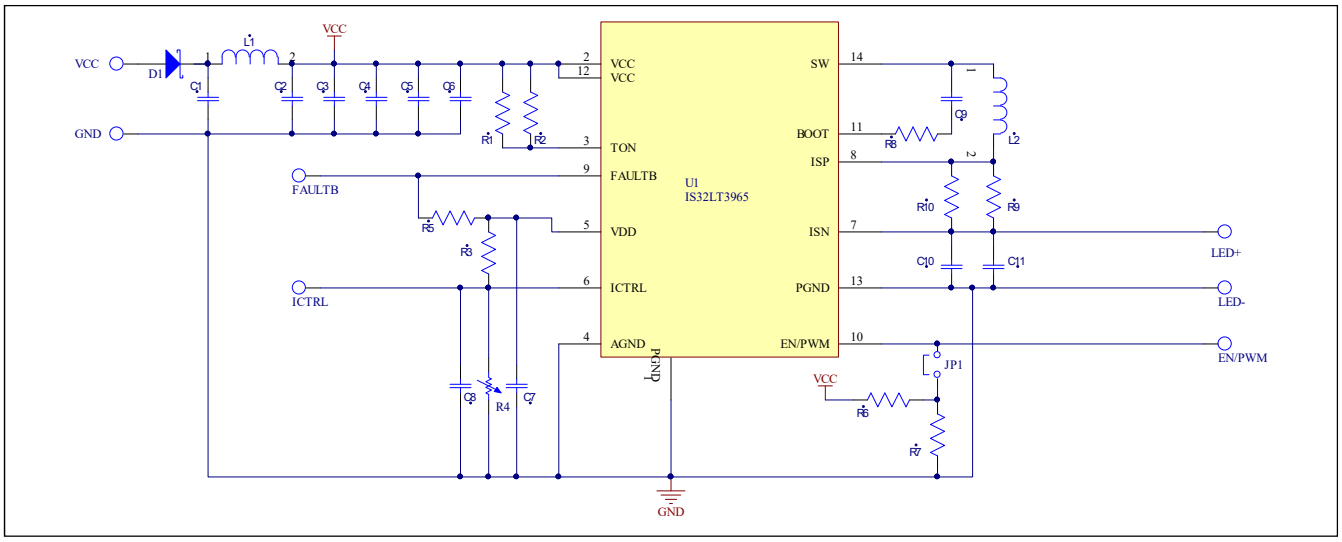

Figure 3 *IS32LT3965 Demo Board Schematic*

BILL OF MATERIALS

Name	Symbol	Description	Qty	Supplier	Part No.
IC	U1	Constant current LED driver	1	Lumissil	IS32LT3965-QWCLA3-TR
Capacitor	C1,C2,C3, C6,C10	CAP,1μF,50V,±10%,SMD	5	Yageo	AC1206KKX7R9BB105
Capacitor	C4,C5	CAP,100nF,50V,±10%,SMD	2	Yageo	CC0805KRX7R9BB104
Capacitor	C7	CAP,1μF,16V,±10%,SMD	1	Yageo	CC0603KRX7R7BB105
Capacitor	C8	CAP,10nF,50V,±10%,SMD	1	Yageo	AC0603KKX7R9BB103
Capacitor	C9	CAP,100nF,50V,±10%,SMD	1	Yageo	AC0603KKX7R9BB104
Capacitor	C11	CAP,10nF,50V,±10%,SMD	1	Yageo	AC0805KKX7R9BB103
Resistor	R1	RES,120k,1/16W,±5%,SMD	1	Yageo	AC0603FR-07120KL
Resistor	R3,R5,R7	RES,10k,1/16W,±5%,SMD	3	Yageo	AC0603JR-0710KL
Resistor	R6	RES,51k,1/16W,±5%,SMD	1	Yageo	AC0603FR-0751KL
Resistor	R8	RES,0R,1/16W,±5%,SMD	1	Yageo	AC0603JR-070RL
Resistor	R9	RES,0.36R,1/4W,±1%,SMD	1	Yageo	RL1206FR-070R36L
Resistor	R10	RES,0.47R,1/4W,±1%,SMD	1	Yageo	RL1206FR-070R47L
Resistor	R2,R4	NC	2		
Diode	D1	3A,60V,SMA	1	Diodes	SS36
Inductor	L1	1kΩ@100MHz,Rate current≥2A	1	Murata	BLM31KN102SN1L
Inductor	L2	3.3μH±20%,Isat≥6A,SMD	1	Coilank	AAPS05A30M3R3

Note: Bill of materials refers to Figure 3 above.

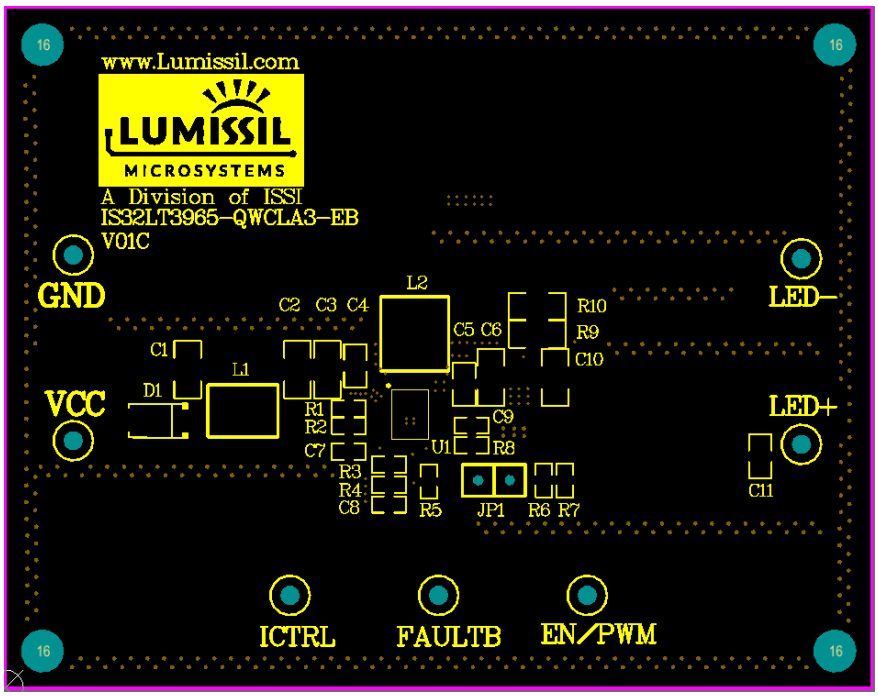

Figure 4 *Board Component Placement Guide - Top Layer*

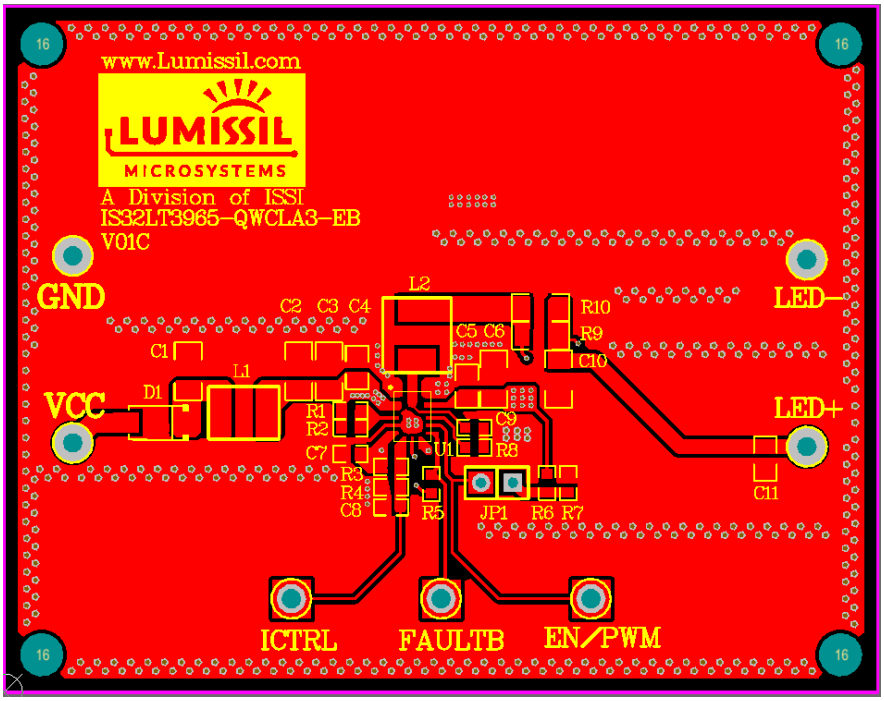

Figure 5 *Board PCB Layout - Top Layer*

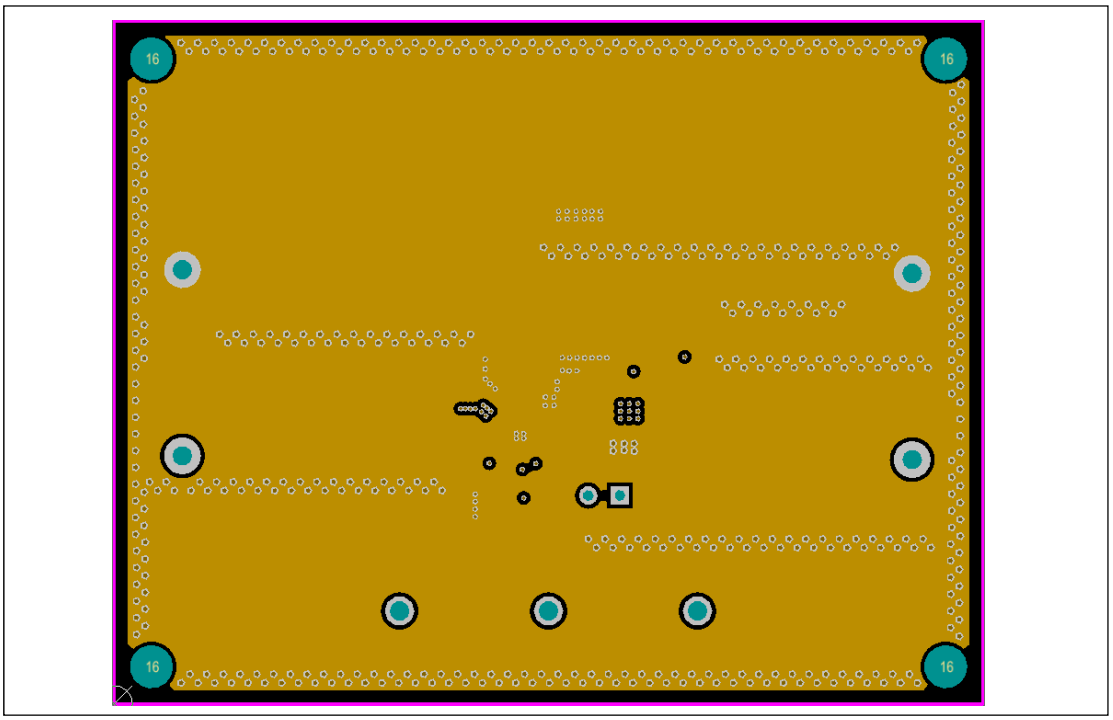

Figure 6 *Board PCB Layout - Mid-Layer 1*

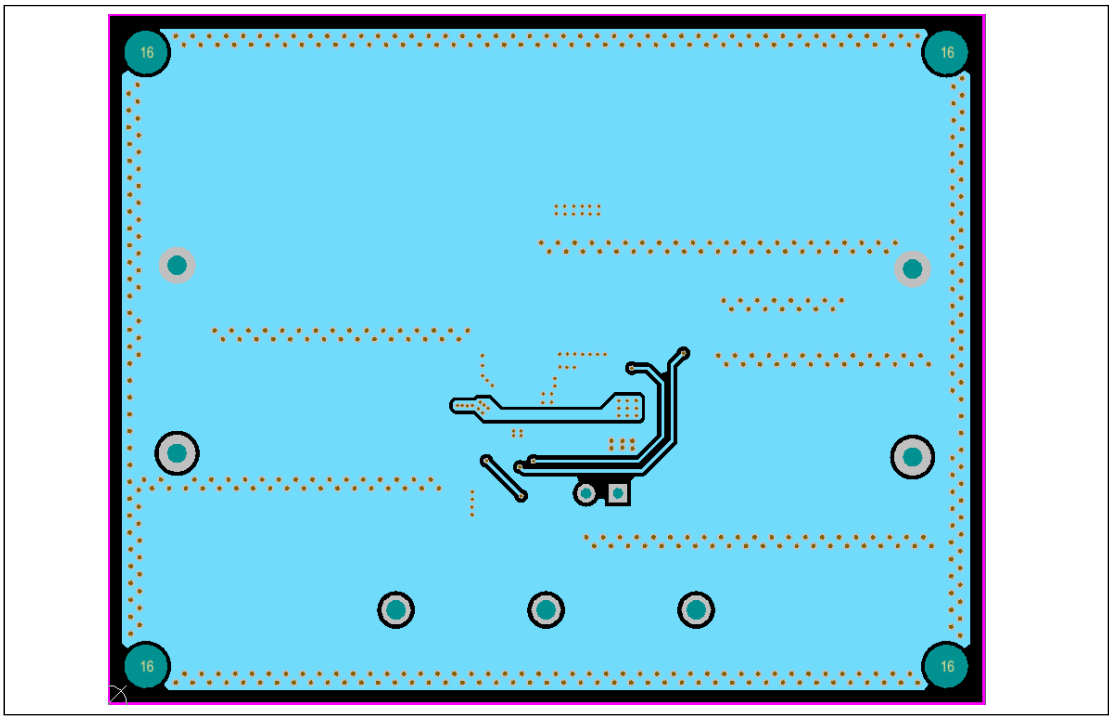

Figure 7 *Board PCB Layout - Mid-Layer 2*

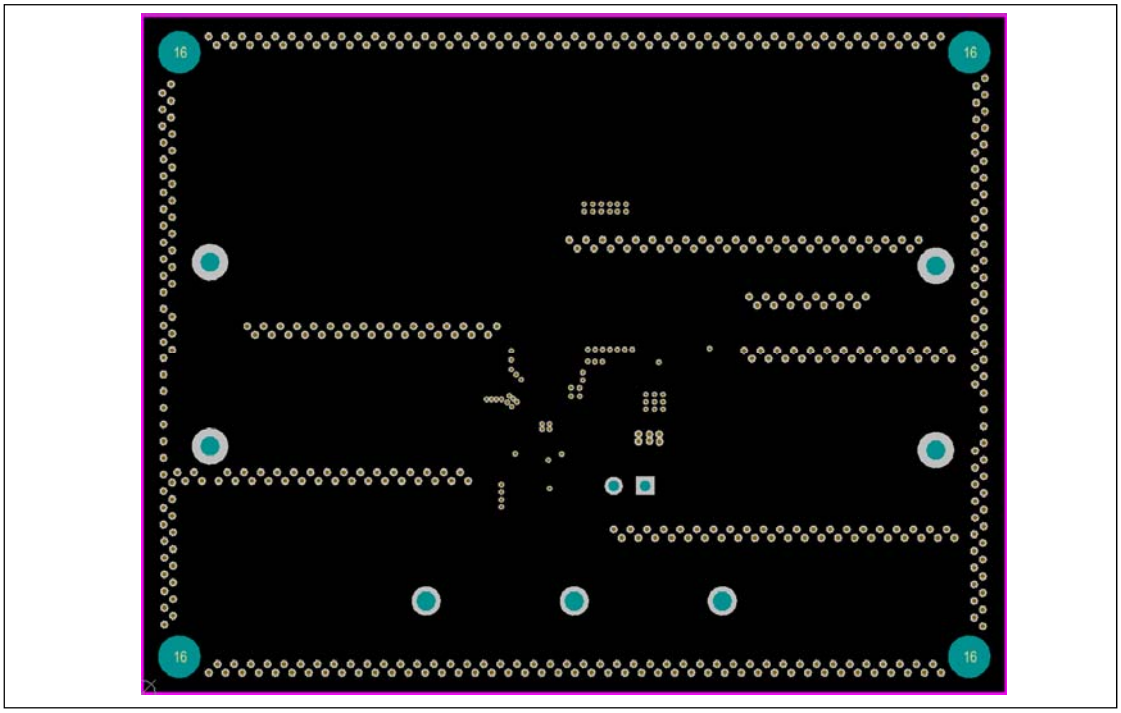

Figure 8 *Board Component Placement Guide - Bottom Layer*

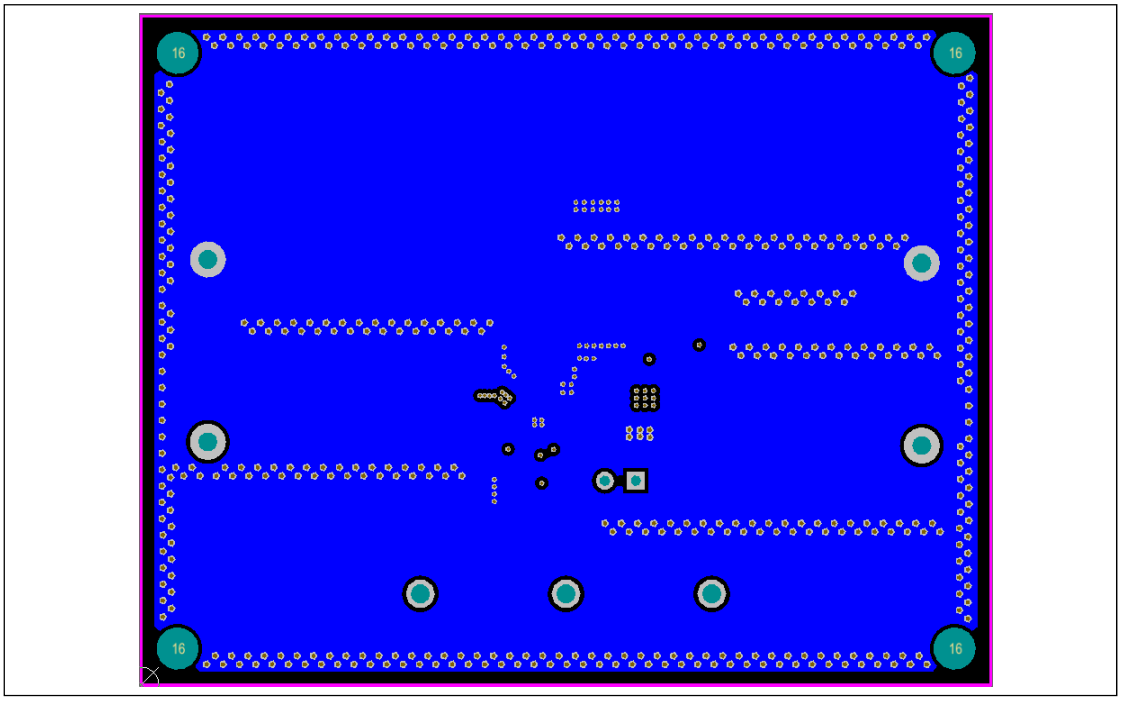

Figure 9 *Board PCB Layout - Bottom Layer*

CONDUCTED EMI PERFORMANCE

Test condition: V_{IN}= 12V, V_{LED}= 6V, I_{LED}= 1A, f_{SW}= 2.2MHz, naked board without any shielding.

Test standard: CISPR-25 Class 5 conducted EMI (Blue: Peak scanning, Red: Average scanning).

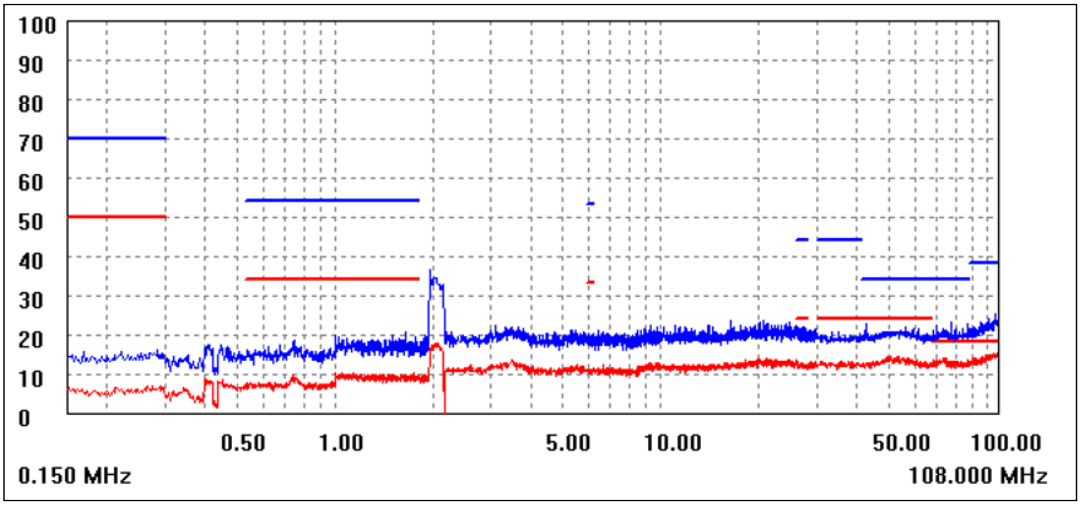

Figure 10 *CISPR-25 Class 5 Conducted EMI Scan (VIN+)*

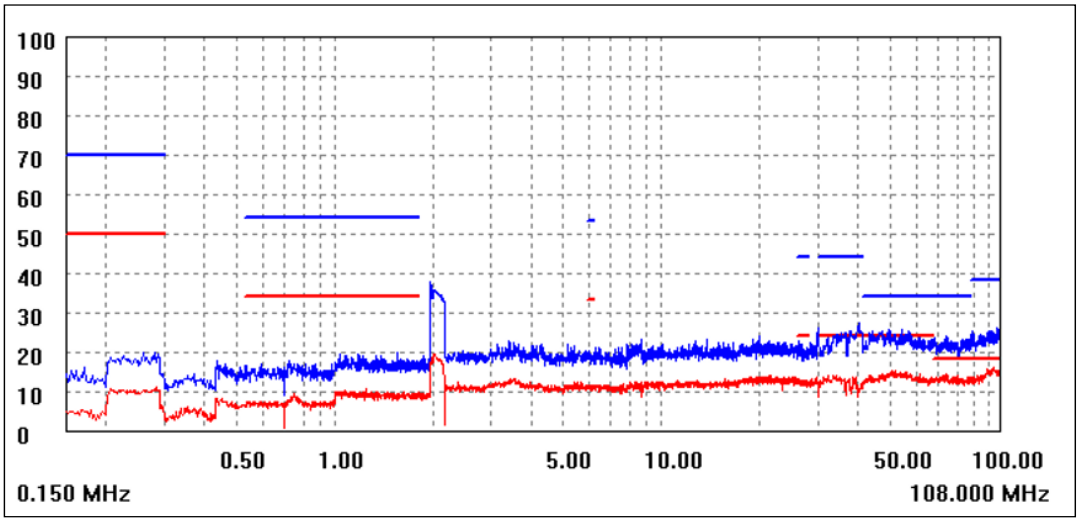

Figure 11 *CISPR-25 Class 5 Conducted EMI Scan (VIN-)*

REVISION HISTORY

Revision	Detail Information	Date
A	Initial release	2023.02.21